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Orthopaedic Surgery Attrition Before Board Certification: A National-Cohort Study of US MD Graduates in Orthopaedic Surgery Residency Programs

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Introduction: Little is known about attrition before American Board of Orthopaedic Surgery (ABOS) board certification for orthopaedic residents training in Accreditation Council for Graduate Medical Education (ACGME)-accredited orthopaedics programs. This national-cohort study examined orthopaedic surgery attrition, associated risk factors, and specialties pursued by residents who left orthopaedics.

Methods: From August 2022 through July 2023, we analyzed deidentified, individual-level data from the Association of American Medical Colleges for 129,860 US MD-granting medical-school matriculants in academic years 1993 to 1994 through 2000 to 2001. Graduates with records of training ≥1 year in orthopaedic surgery during GME and of board certification as of May 2020 were included. Retention was defined as being ABOS-certified; attrition was defined as being certified by another specialty board and not ABOS. We identified variables independently associated with attrition from orthopaedics using multivariable logistic regression analysis and reported adjusted odds ratios (OR) and 95% confidence intervals (CI).

continued

This study used data from multiple sources (AAMC, NBME, AMA, and ABMS); Dr. Jeffe received all data from the AAMC. The statistical analyses, interpretation of findings, and views expressed herein are those of the authors and do not necessarily reflect the position or policy of the AAMC, NBME, AMA, ABMS, National Institutes of Health National Institute of General Medical Sciences (NIH NIGMS), or any of their respective staff members. The NIH NIGMS was not involved in the design or conduct of the study; collection, management, analysis, or interpretation of the data; or in the preparation, review, or approval of the manuscript.

Data were used with permission from each outside source. As part of the data use agreement with each source, the source's staff reviewed the manuscript before submission.

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Results: Of 4,319 US medical-school graduates from 1997 to 2009 with ≥1 year of orthopaedic surgery GME, 4,085 (94.6%) obtained ABOS board certification (retention) and 234 did not (attrition). Women (OR 2.8, 95% CI 2.0-3.9), first-generation college graduates (OR 1.6, 95% CI 1.1-2.2), Asians (OR 1.9, 95% CI 1.4-2.7), and residents who placed greater importance on innovation/research in choosing medicine as a career (OR 1.4, 95% CI 1.1-1.7) and completed ≥1 year of research during GME (OR 2.4, 95% CI 1.7-3.5) were more likely to leave orthopaedics. Overall, 121 trainees who left orthopaedics selected surgical specialties for board certification, most commonly plastic surgery (n = 66) and general surgery (n = 45).

Conclusions: The increased risk of attrition among women, Asians, first-generation college graduates, and trainees endorsing higher importance of innovation/research in choosing medicine and participating in research during GME raises concerns about the potential loss of underrepresented groups among orthopaedic surgeons and surgeon-scientists. Efforts to mitigate attrition among residents in high-risk groups are warranted.

Introduction

Attrition because of residents changing specialties or leaving Graduate Medical Education (GME) entirely has significant ramifications for training programs. Orthopaedics is a highly competitive GME specialty[1,2], and orthopaedic programs have a small number of residents. Resident attrition leads to disruptions in resident coverage causing staffing challenges affecting patients and other trainees[3]. Given that Medicare supports a limited number of resident positions, there is little flexibility in bringing on additional residents to fill potential gaps[4]. Consequently, it is important to identify residents at risk of attrition and take measures to support them.

Residency program directors have little information about trainee attrition. In a single-institutional, retrospective-cohort study of graduates entering GME programs across all specialties, there was a 6% attrition rate from residents' initial specialty of choice, with residents pursuing surgical-subspecialty training at increased risk of attrition[5]. A survey of orthopaedic surgery program directors found that, from 1998 to 2013, women were more likely than men to leave orthopaedics[6]. Similar research has been limited primarily to program director surveys, which have largely attributed attrition to lifestyle and work-hour issues[6-8]. These studies were limited by program director response and recall bias and short study periods, and they have not reported academic or experiential risk factors on a national scale.

Retention and attrition from GME ultimately shape the population of board-certified orthopaedic surgeons[9]. The American Board of Medical Specialties (ABMS) engages with its member specialty boards to improve the quality of GME training and medical practice standards, to ensure that board-certified physicians demonstrate high levels of knowledge and expertise, promote patient safety, and provide patients with high-quality care[9]. Given the importance of board certification on practice quality, we define retention and attrition in our study based on board-certification data.

In this national-cohort study, we aimed to describe (1) the overall prevalence of attrition from orthopaedic surgery among residents who trained in orthopaedics but did not become board-certified by the American Board of Orthopaedic Surgery (ABOS), (2) the specialties ultimately pursued by those residents who left orthopaedic surgery, and (3) risk factors independently associated with attrition from orthopaedic surgery.

Methods

We conducted a secondary analysis of existing individual-level data from various sources for a national-cohort study of 129,860 matriculating students in US MD-granting medical schools in academic years 1993 to 1994 through 2000 to 2001; for analysis, we included matriculants who graduated in 1997 or later. This cohort study allowed sufficient time for students to graduate and achieve long-term outcomes (e.g., specialty board certification, faculty appointment/promotion, and research grant awards). The Association of American Medical Colleges (AAMC) staff provided deidentified data to the investigators, linked for each individual using a unique ID. The study was approved by the Institutional Review Board at Washington University in St. Louis, and reporting guidelines for observational studies were followed[10].

Measures

From the American Medical College Application Service[11], we obtained data for self-reported sex (female or male) and race/ethnicity (categorized as White, Asian, URiM [including Black/African American, Pacific Islanders, Hispanic/Latino, American Indian/Native Alaskan], or other/unknown/no response).

From the AAMC Matriculating Student Questionnaire (MSQ)[12], completed voluntarily by incoming medical students, we examined parental education (first-generation college graduate [neither parent completed 4-year BA/BS degree] or continuing-generation college graduate [at least one parent completed BA/BS degree, with or without further graduate or professional education]). We also included 2 multiitem measures for the importance of innovation/research and of social responsibility in students' choice of medicine as a career[13]. Mean scores range from 0 to 4; higher scores indicate greater importance. MSQ response rates averaged 94% in this cohort[14].

From the AAMC Graduation Questionnaire (GQ)[14], completed voluntarily by graduating medical students, we examined total debt at graduation (categorized as no debt, $1 to $99,999, ≥$100,000, or missing). We also examined research and authorship activities using 2 GQ items about participation in research with faculty and authorship during medical school (categorized as

participating in neither research nor authorship activity, participating in one or both of research and authorship, and missing). As GQ response rates averaged about 70% in this cohort (David Matthew, PhD, personal communication, August 2022), we created a missing data category for GQ variables in our analysis to reduce risk of bias in our findings.

From the National Board of Medical Examiners (NBME), we obtained first-attempt, 3-digit US Medical Licensing Examination (USMLE) Step 1 scores. We created a 5-category variable for analysis, based on cutoff passing scores for each year in which Step 1 was completed (highest, second-highest, third-highest, and lowest quartile passing and failing scores).

From the AAMC's GME Track database[15], we obtained information about trainee specialty and whether a trainee participated in dedicated research year(s) during GME. GME Track includes residency training data collected during the National GME Census, an annual survey jointly conducted by the AAMC and the American Medical Association (AMA). The National GME Census is completed voluntarily by Accreditation Council for Graduate Medical Education–accredited residency program directors and institutional officials, providing information about each trainee and program, with response rates averaging 92% annually (Lindsay Roskovensky, BA, personal communication, September 2023).

Using GME Track and ABMS board-certification data received June 3, 2020, we compared attrition vs. retention in orthopaedic surgery among those residents who trained in orthopaedic surgery during GME. We defined retention in orthopaedic surgery as obtaining ABOS board certification and attrition from orthopaedic surgery as obtaining board certification by another ABMS member board and not by ABOS. Recognizing that not all physicians practicing in orthopaedic surgery are ABOS board-certified, given the goal of GME training to produce board-certified physicians and the importance of board certification to promote practice quality and safety, our outcome focused on ABOS board certification.

For comparison, we similarly calculated retention and attrition rates for residents who had trained in other surgical specialties, including plastic surgery, neurosurgery, otolaryngology, urology, thoracic surgery, and ophthalmology. Retention in and attrition from each of these surgical specialties were defined as they were for orthopaedic surgery.

Data Analysis

We describe associations between attrition from (vs. retention in) orthopaedic surgery and categorical variables of interest using chi-square tests, reporting frequencies (%). We describe between-group differences between attrition and retention using one-way analyses of variance for continuous variables of interest, reporting mean values (SD). We ran a multivariable logistic regression model to identify variables independently associated with attrition from (vs. retention in) orthopaedic surgery, reporting adjusted odds ratios (ORs) and 95% confidence intervals (CIs). Analyses were performed using IBM SPSS Statistics, version 28.0.0.0 (IBM Corp., Armonk, NY). We considered 2-sided p values <0.05 as statistically significant.

Sources of Funding

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Results

Of 125,198 students in this cohort who graduated in 1997 or later, 4,894 had a record of GME training in orthopaedic surgery, each of whom graduated between 1997 and 2009 and had at least 11 years of follow-up by 2020. Of these 4,894 trainees, 239 graduates lacked a record of ABMS board-certification data for any specialty and were excluded. The remaining 4,675 graduates comprised those who obtained ABOS board certification (the orthopaedic surgery retention group) or those who became board-certified by another ABMS member board and not ABOS (the attrition group). We included 20 graduates in the retention group because they were board-certified by ABOS, although they lacked any record of GME training (n = 10) or had GME Track data but no record

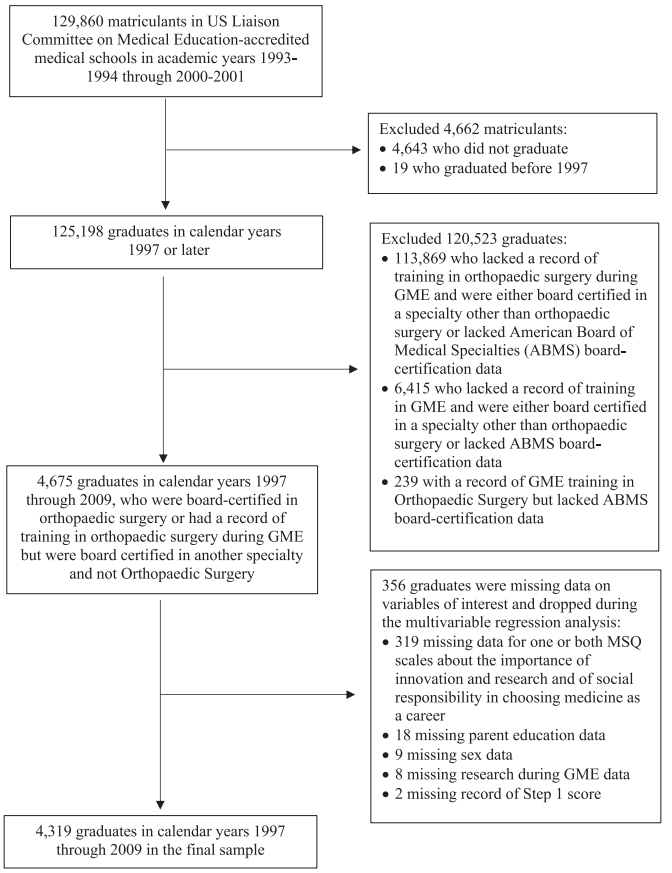

Fig. 1

Flow diagram of selection for eligibility and inclusion in analysis

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TABLE I Variables of Interest and Their Bivariate Associations with Orthopaedic Surgery Retention and Attrition Among the United States*

	Total N = 4,319	Retention N = 4,085	Attrition N = 234	p†
Sex, no. (%)				<0.001
Male	3,902 (90.3)	3,719 (95.3)	183 (4.7)	
Female	417 (9.7)	366 (87.8)	51 (12.2)	
Race/ethnicity, no. (%)				
White	3,327 (77.0)	3,169 (95.3)	158 (4.7)	<0.001
Asian	559 (12.9)	509 (91.1)	50 (8.9)	
URiM	383 (8.9)	361 (94.3)	22 (5.7)	
Other/unknown/no response	50 (1.2)	46 (92.0)	4 (8.0)	
Parent education, no. (%)				0.04
Continuing-generation college graduate	3,638 (84.2)	3,452 (94.9)	186 (5.1)	
First-generation college graduate	681 (15.8)	633 (93.0)	48 (7.0)	
Importance of innovation/research in choosing medicine, mean (SD)	4,319 (100.0)	2.9 (0.6)	3.0 (0.6)	0.004
Importance of social responsibility in choosing medicine, mean (SD)	4,319 (100.0)	3.2 (0.6)	3.3 (0.6)	0.04
Total debt at graduation, no. (%)				0.04
No debt	657 (15.2)	609 (92.7)	48 (7.3)	
$1-$99,999	1,471 (34.0)	1,402 (95.3)	69 (4.7)	
≥$100,000	1,523 (35.3)	1,446(94.9)	77 (5.1)	
Missing/no response	668 (15.5)	628 (94.0)	40 (6.0)	
Research and/or authorship elective during medical school, no. (%)				0.04
Neither elective reported	563 (13.0)	523 (92.9)	40 (7.1)	
One or both electives	3,126 (72.4)	2,973 (95.1)	153 (4.9)	
Missing	630 (14.6)	589 (93.5)	41 (6.5)	
First-attempt USMLE Step 1 scores				<0.001
Highest quartile of passing	1,931 (44.7)	1,841 (95.3)	90 (4.7)	
Second-highest quartile of passing	1,307 (30.3)	1,245 (95.3)	62 (4.7)	
Third-highest quartile of passing	728 (16.9)	679 (93.3)	49 (6.7)	
Lowest quartile of passing	319 (7.4)	292 (91.5)	27 (8.5)	
Failing	34 (0.8)	28 (82.4)	6 (17.6)	
Has record of ≥1 year of research during GME, no. (%)				<0.001
No	3,990 (92.4)	3,796 (95.1)	194 (4.9)	
Yes	329 (7.6)	289 (87.8)	40 (12.2)	

*LCME-accredited medical-school graduates in calendar years 1997 through 2009 who completed at least 1 year of orthopaedic surgery GME training and had a record of ABMS specialty board certification.† GME = Graduate Medical Education, LCME = Liaison Committee on Medical Education, URiM = Underrepresented in Medicine (Black/African American, Pacific Islanders, Hispanic/Latino, American Indian/Alaska Native), and USMLE = US Medical Licensing Examination. †Chi-square tests measured associations between categorical variables and the outcome; analysis of variance measured differences in mean scores of the importance of factors in choosing medicine as a career, by the outcome. †Percentages of the row totals are shown.

of training in orthopaedic surgery (n = 10); these graduates were assumed to have completed the required GME training for board certification by the ABOS[9]. We further limited our sample to graduates who had complete data for variables of interest. Thus, our final sample included 4,319 graduates in calendar years 1997 through 2009, 4,085 in the retention group and 234 in the attrition group (Fig. 1).

Table I shows descriptive statistics for each variable of interest stratified by retention and attrition. In the attrition group, there were greater proportions of graduates who were female, Asian, first-generation college graduates, had no debt at graduation, did not report research/authorship electives during medical school, failed Step 1, and completed ≥1 year of research during GME. Attrition was also associated with greater importance of innovation/research and of social responsibility in choosing medicine as a career.

Table II shows the results of the multivariable logistic regression model. A greater likelihood of orthopaedic surgery attrition was observed among women, Asians, first-generation college graduates, and graduates who placed greater

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TABLE II Multivariable Logistic Regression Analysis to Identify Variables Independently Associated with Attrition From (vs. Retention in) Orthopaedic Surgery Among the United States*

	Orthopaedic Surgery Attrition aOR (95% CI)	p
Sex		
Male	1.0 (reference)	
Female	2.8 (2.0-3.9)	<0.001
Race/ethnicity		
White	1.0 (reference)	
Asian	1.9 (1.4-2.7)	<0.001
URiM	1.0 (0.6-1.5)	0.82
Other/unknown/no response	1.7 (0.6-4.8)	0.35
Parent education		
Continuing-generation college graduate	1.0 (reference)	
First-generation college graduate	1.6 (1.1-2.2)	0.01
Importance of innovation and research in choosing medicine	1.4 (1.1-1.7)†	0.01
Importance of social responsibility in choosing medicine	1.0 (0.8-1.3)	0.82
Total debt at graduation		
No debt	1.0 (reference)	
$1-$99,999	0.7 (0.4-1.0)	0.04
≥$100,000	0.7 (0.5-1.0)	0.06
Missing/no response	0.5 (0.2-1.4)	0.19
Research and/or authorship elective during medical school		
Neither elective reported	1.0 (reference)	
One or both electives	0.6 (0.4-0.9)	0.01
Missing	1.0 (0.4-2.7)	0.93
First-attempt, USMLE Step 1 scores		
Highest quartile of passing	1.0 (reference)	
Second-highest quartile of passing	1.0 (0.7-1.4)	0.86
Third-highest quartile of passing	1.0 (1.0-2.1)	0.04
Lowest quartile of passing	1.9 (1.2-3.0)	0.009
Failing	4.8 (1.9-12.6)	0.001
Has record of ≥1 year of research during GME		
No	1.0 (reference)	
Yes	2.4 (1.7-3.5)	<0.001

*LCME-accredited medical-school graduates in calendar years 1997 through 2009 who completed at least 1 year of orthopaedic surgery GME training and had a record of ABMS specialty board certification (N = 4,319). aOR = adjusted odds ratio, CI = confidence interval, GME = Graduate Medical Education, LCME = Liaison Committee on Medical Education, URiM = Underrepresented in Medicine (Black/African American, Pacific Islanders, Hispanic/Latino, American Indian/Alaska Native), and USMLE = US Medical Licensing Examination. †aOR >1.00 denotes greater likelihood of attrition with each unit increase in importance attributed to innovation and research in choosing medicine as a career.

importance on innovation/research in choice of medicine as a career, had failing or low-passing Step 1 scores, and had a record of ≥1 year of research during GME. Trainees who participated in medical-school research and/or authorship activities were less likely to leave orthopaedic surgery compared with students who participated in neither activity.

Retention rates in each of the surgical specialties were high (Fig. 2), with 3 specialties (ophthalmology, urology, and otolaryngology) having higher retention than orthopaedics. The 234 graduates who left orthopaedic surgery became board-certified in various specialties; 121 of these graduates became board-certified in another surgical specialty (Fig. 3).

Discussion

Orthopaedic surgery attrition, based on lack of ABOS board certification, was 5.4% in this national cohort, which was comparable with other surgical specialties. Trainees who left orthopaedic surgery most commonly became board-certified in

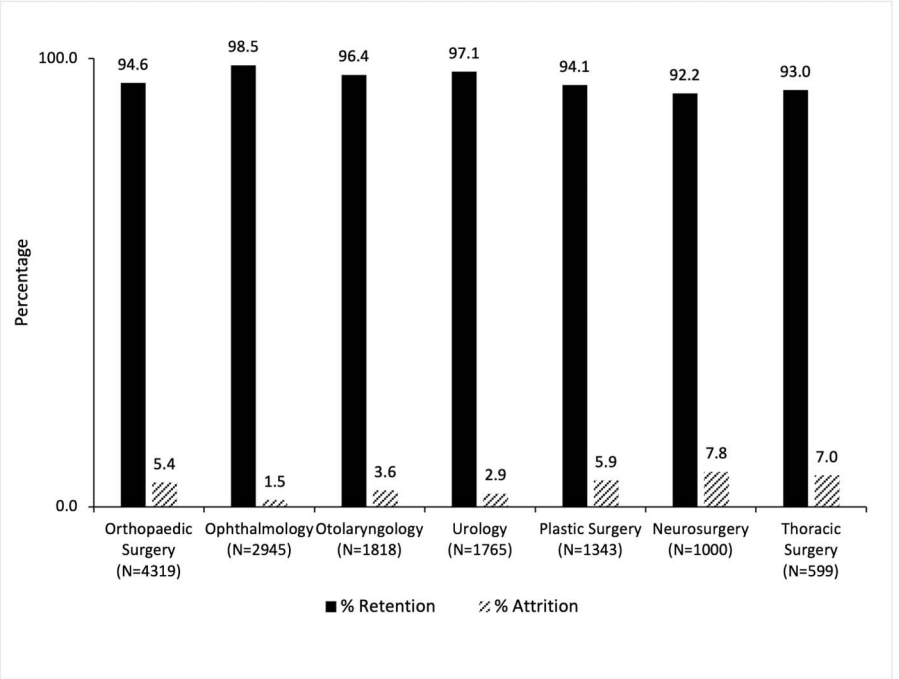

Fig. 2

Rates of retention and attrition among the cohort of US medical-school matriculants in academic years 1993 to 1994 through 2000 to 2001, who graduated in calendar years 1997 or later, trained in each surgical specialty during GME, and had American Board of Medical Specialties board-certification data by May 2020, either in that specialty (retention) or only in another specialty (attrition).

other surgical specialties (e.g., plastic surgery and general surgery). Independent risk factors for orthopaedic surgery attrition included being a woman, Asian, and first-generation college graduate, raising concerns about a greater risk of attrition among residents from underrepresented groups in orthopaedic surgery. In addition, matriculants who placed greater importance on innovation/research or completed ≥1 year of research during GME were more likely to leave orthopaedic surgery, which could represent a loss of future academic surgeons and surgeon-scientists in orthopaedic surgery.

The overall prevalence of orthopaedic surgery attrition surgery was comparable with attrition rates from other surgical specialties in our study. The most commonly chosen specialty for eventual board certification among residents leaving orthopaedics was plastic surgery. These 2 specialties are highly collaborative with considerable overlap in their clinical scope of practice. For

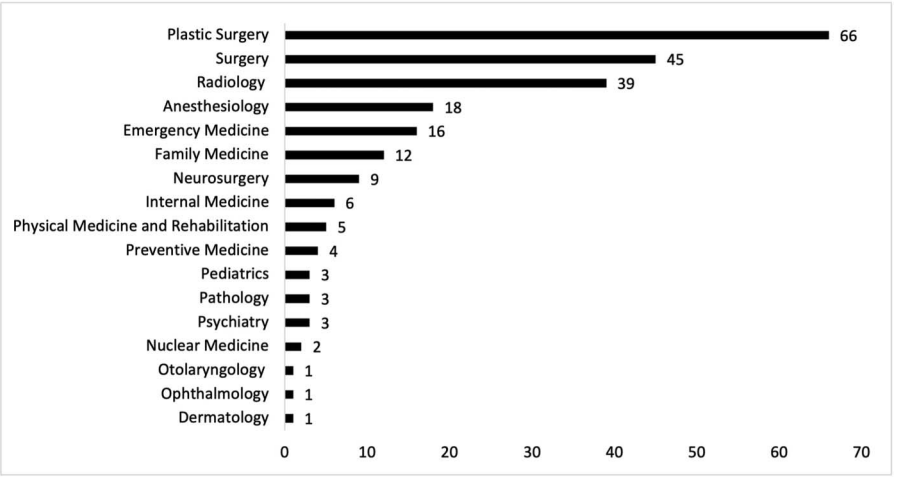

Fig. 3

Frequencies of graduates who trained in orthopaedic surgery during residency but were board-certified by another American Board of Medical Specialties member board, without a record of board certification in orthopaedic surgery (N = 234).

example, the burden of hand surgery call is typically split between the 2 specialties, and plastic surgeons work closely with orthopaedic surgeons for soft-tissue wound coverage and management of complex extremity trauma[16,17]. We observed that general surgery was the second most commonly chosen specialty for board certification in residents who left orthopaedics. In a systematic review of resident attrition during general surgery GME, the pooled estimate of attrition prevalence was much higher, at 18%[8], than what we observed in other surgical specialties. Despite its higher attrition rates, general surgery seems to be an attractive alternative to orthopaedic surgery. We recommend further research to better characterize reasons that these other surgical specialties might attract orthopaedic surgery trainees to other fields.

We found that women, Asians, and first-generation college graduates were at higher risk of attrition than men, White, and continuing-generation college graduates, respectively. This is consistent with previous program director surveys, which demonstrated that women are at higher risk of attrition from orthopaedic surgery training programs than men are[6]. Across all surgical specialties, women and URiM residents were at greater risk of attrition from residency programs (compared with men and White residents, respectively)[18]. Although URiM residents were not at greater risk of attrition in our study, Asian residents were at greater risk of attrition, and Asians are an underrepresented group within orthopaedics[19,20]. Considering culture/climate factors that could lead to greater risk of attrition for high-risk groups is important. In general surgery, URiM (vs. White) residents were less likely to feel a sense of community and fit within their programs, and women (vs. men) were less likely to report collegial relationships with their faculty members[21,22]. In a workplace climate survey of American Academy of Orthopaedic Surgeons members in training and in practice, women reported much higher rates of discrimination, bullying, harassment, and sexual harassment compared with men[23]. These findings raise concern that orthopaedic residents from underrepresented groups may be experiencing multiple aspects of a hostile work culture.

First-attempt USMLE Step 1 failing and lower passing scores also were observed to be associated with orthopaedic surgery attrition in this cohort. Although the NBME now reports Step 1 as pass/fail, the impact of Step 1 scores on long-term outcomes is clear. Beyond its historical use by program directors as a measure of academic achievement for the purpose of matching students into their specialty of choice, higher Step 1 scores are associated with long-term outcomes, including board certification in multiple specialties[24,25], faculty appointment/promotion[26,27], and obtaining research grant awards[28], although Step 1 scores are not used directly as a criterion for these achievements. Further research is needed to investigate whether and how changing Step 1 score reporting to pass/fail will affect long-term outcomes such as board certification.

We found a greater risk of attrition from orthopaedic surgery among residents who completed ≥1 research year during GME and who placed greater importance on innovation/research in choosing medicine as a career at medical-school matriculation, which could lead to loss of surgeon-scientists in the orthopaedic surgery training pipeline. Interestingly, trainees who participated in research and/or authorship activities during medical school were much less likely to have left orthopaedics, defined here as not becoming ABOS board-certified. Losing orthopaedic surgeon-scientists could be part of a larger trend of losing surgeon-scientists across surgical specialties, evidenced by declining NIH funding to surgical departments and fewer surgeons applying for and receiving NIH K-awards compared with nonsurgeon peers[29-31].

This surgeon-scientist workforce issue is noteworthy because many medical students aiming to match in competitive residency programs, including orthopaedic surgery, participate in research/authorship activities during medical school, which was associated with a lower likelihood of attrition from orthopaedic surgery. Whether orthopaedic surgery residents who participate in research during GME feel relatively unsupported in their GME research endeavors compared with potentially more positive research/authorship experiences during medical school requires further study. Potential challenges confronting surgeon-scientists include increased competition for grant funding, balancing research demands with clinical productivity, changing expectations regarding work-life balance, and perceived reduction in departmental and institutional support[29,30]. Given the value of surgeon-scientists in research discovery/innovation, orthopaedic surgery may benefit from additional support for residents engaged in research, such as protected research time, funding support, and mentorship[32].

Limitations

The use of individual-level, national-cohort data strengthens the quality and generalizability of our findings; nevertheless, our study has several limitations. Although the AAMC, NBME, AMA, and ABMS are rich sources of data, we were limited to using only variables available in the existing database, which was constructed for a national-cohort study with different specific aims. As a cohort study reporting associations among variables, we cannot infer causation from our findings. Although the National GME Census Resident Survey typically has high response rates[16], this survey may not be completed annually for each resident in a program; thus, longitudinal data for trainees may be incomplete. Regardless, the goal of orthopaedic training is to train board-certified surgeons, and all graduates in this national cohort who had a record of GME training in orthopaedic surgery had a minimum of 11 years to become ABOS board-certified by 2020, when we received updated ABMS board-certification data. Using ABOS board-certification data is a strength of this study because it comes from the national certifying board and is not self-reported data, which is prone to bias and missingness. We identified several independent risk factors for orthopaedic surgery attrition but could not examine specific reasons why individuals left orthopaedics. Understanding individuals' reasons for attrition is an

important area for future research, to better support trainees at risk of attrition.

Conclusions

Although the rate of orthopaedic surgery attrition in this cohort was similar to attrition from other surgical specialties, several factors placed trainees at risk of attrition. Women, Asians, and first-generation college graduates were at greater risk of orthopaedic surgery attrition. Further investigation is needed regarding stressors that orthopaedic surgery residents experience, such as a lack of inclusiveness and mentoring for underrepresented residents[21-23,33]. Trainees who placed greater importance on innovation/research in choosing medicine as a career and residents who completed ≥1 year of research during GME were less likely to become board-certified in orthopaedic surgery and this may forecast a loss of surgeon-scientists in the orthopaedic surgery training pipeline. Overall, our findings demonstrate a need for orthopaedic surgery educators, program directors, educational institutions, and other professional organizations to identify and support trainees at risk of attrition to increase rates of board certification in orthopaedic surgery, not only to promote high-quality practice and safety but also to address workforce concerns about diversity and inclusion. ■

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References

1. The National Resident Matching Program. Charting outcomes in the match: senior students of U.S. MD medical schools; 2022. Available at: https://www.nrmp.org/wp-content/uploads/2022/07/Charting-Outcomes-MD-Seniors-2022_Final.pdf. Accessed August 6, 2023.

2. National Resident Matching Program. National resident matching program, results and data: 2022 main residency match; 2022. Available at: https://www.nrmp.org/wp-content/uploads/2022/11/2022-Main-Match-Results-and-Data-Final-Revised.pdf. Accessed August 6, 2023.

3. Doximity. Orthopaedic surgery residency programs: residency navigator; 2023. Available at: https://www.doximity.com/residency/specialties/bd234238-6960-4260-9475-1fa18f58f092-orthopaedic-surgery. Accessed August 2, 2023.

4. Association of American Medical Colleges. Medicare payments for graduate medical education: what every medical student, resident, and advisor needs to know; 2019. Available at: https://www.aamc.org/data-reports/faculty-institutions/report/medicare-payments-graduate-medical-education-what-every-medical-student-resident-and-advisor-needs. Accessed February 13, 2023.

5. Andriole DA, Jeffe DB, Hageman HL, Klingensmith ME, McAlister RP, Whelan AJ. Attrition during graduate medical education: medical school perspective. Arch Surg. 2008;143(12):1172-7.

6. Bauer JM, Holt GE. National orthopedic residency attrition: who is at risk? J Surg Educ. 2016;73(5):852-7.

7. Yang MK, Meyerson JM, Pearson GD. Resident attrition in plastic surgery: a national survey of plastic surgery program directors. Ann Plast Surg. 2018;81(3):360-3.

8. Khoushhal Z, Hussain MA, Greco E, Mamdani M, Verma S, Rotstein O, Tricco AC, Al-Omran M. Prevalence and causes of attrition among surgical residents: a systematic review and meta-analysis. JAMA Surg. 2017;152(3):265-72.

9. American Board of Medical Specialties. ABMS Guide to Medical Specialties; 2022. Available at: https://www.abms.org/wp-content/uploads/2021/12/ABMS-Guide-to-Medical-Specialties-2022.pdf. Accessed February 9, 2023.

10. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. PLoS Med. 2007;4(10):e296.

11. American Medical College Application Service. Applying to medical school with AMCAS. Available at: https://students-residents.aamc.org/applying-medical-school-amcas/applying-medical-school-amcas. Accessed February 7, 2023.

12. Association of American Medical Colleges. Matriculating Student Questionnaire (MSQ); 2022. Available at: https://www.aamc.org/data-reports/students-residents/report/matriculating-student-questionnaire-msq. Accessed September 9, 2023.

13. Jeffe DB, Whelan AJ, Andriole DA. Primary care specialty choices of United States medical graduates, 1997-2006. Acad Med. 2010;85(6):947-58.

14. Association of American Medical Colleges. Graduation Questionnaire (GQ); 2022. Available at: https://www.aamc.org/data-reports/students-residents/report/graduation-questionnaire-gq. Accessed September 9, 2023.

15. Association of American Medical Colleges. GME Track. Available at: https://www.aamc.org/data-reports/students-residents/report/gme-track. Accessed September 9, 2023.

16. Sommar P, Granberg Y, Halle M, Skogh ACD, Lundgren KT, Jansson KÅ. Effects of a formalized collaboration between plastic and orthopedic surgeons in severe extremity trauma patients; a retrospective study. J Trauma Manag Outcomes. 2015;9(1):3.

17. Dasari CR, Sandhu M, Wisner DH, Wong MS. Approaches to distal upper-extremity trauma: a comparison of plastic, orthopedic, and hand surgeons in academic practice. Ann Plast Surg. 2016;76(suppl 3):S162-S164.

18. Haruno LS, Chen X, Metzger M, Lin CA, Little MTM, Kanim LEA, Poon SC. Racial and sex disparities in resident attrition among surgical subspecialties. JAMA Surg. 2023;158(4):368-76.

19. Okike K, Utuk ME, White AA. Racial and ethnic diversity in orthopaedic surgery residency programs. J Bone Joint Surg Am. 2011;93(18):e107.

20. Association of American Medical Colleges. Underrepresented in Medicine Definition. Available at: https://www.aamc.org/what-we-do/equity-diversity-inclusion/underrepresented-in-medicine. Accessed July 14, 2023.

21. Wong RL, Sullivan MC, Yeo HL, Roman SA, Bell RH, Sosa JA. Race and surgical residency: results from a national survey of 4339 US general surgery residents. Ann Surg. 2013;257(4):782-7.

22. Sullivan MC, Bucholz EM, Yeo H, Roman SA, Bell RH, Sosa JA. "Join the club": effect of resident and attending social interactions on overall satisfaction among 4390 general surgery residents. Arch Surg. 2012;147(5):408-14.

23. Balch Samora J, Van Heest A, Weber K, Ross W, Huff T, Carter C. Harassment, discrimination, and bullying in orthopaedics: a work environment and culture survey. J Am Acad Orthop Surg. 2020;28(24):e1097-e1104.

24. Jeffe DB, Andriole DA. Factors associated with American board of medical specialties member board certification among US medical school graduates. JAMA. 2011;306(9):961-70.

25. Andriole DA, Jeffe DB. Certification by the American Board of Surgery among US medical school graduates. J Am Coll Surg. 2012;214(5):806-15.

26. Andriole DA, Jeffe DB. The road to an academic medicine career: a national cohort study of male and female U.S. medical graduates. Acad Med. 2012;87(12):1722-33.

27. Jeffe DB, Yan Y, Andriole DA. Competing risks analysis of promotion and attrition in academic medicine: a national study of U.S. Medical school graduates. Acad Med. 2019;94(2):227-36.

28. Jeffe DB, Andriole DA. Prevalence and predictors of US medical graduates' federal F32, mentored-K, and R01 awards: a national cohort study. J Invest Med. 2018;66(2):340-50.

29. Woldu SL, Raj GV. Surgery: the surgeon-scientist–a dying breed? Nat Rev Urol. 2016;13(12):698-9.

30. Keswani SG, Moles CM, Morowitz M, Zeh H, Kuo JS, Levine MH, Cheng LS, Hackam DJ, Ahuja N, Goldstein AM, Basic Science Committee of the Society of University Surgeons. The future of basic science in academic surgery: identifying barriers to success for surgeon-scientists. Ann Surg. 2017;265(6):1053-9.

31. Rangel SJ, Moss RL. Recent trends in the funding and utilization of NIH career development awards by surgical faculty. Surgery. 2004;136(2):232-9.

32. Baker NF, Colazo JM, Gosain AK. Beyond the scalpel: attracting and nurturing surgeon-scientists in plastic surgery. Plast Reconstr Surg. 2022;149(2):509-16.

33. Rohde RS, Wolf JM, Adams JE. Where are the women in orthopaedic surgery? Clin Orthop Relat Res. 2016;474(9):1950-6.